

DESCRIPTION

HYDROGEN COMBUSTION DEVICE HAVING HYDROGEN PIPE

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Technical Field

The present invention relates to a hydrogen combustion device for generating oxidative reaction heat of hydrogen-gas by a catalyst. More particularly, the present invention relates to a hydrogen pipe arranged in the hydrogen combustion device to introduce hydrogen from a hydrogen source into the hydrogen combustion device.

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Background Art

As the conventional hydrogen combustion device, Japanese Patent Application Laid-open No. 2002-122311 discloses one hydrogen combustion device that allows mixed gas of hydrogen gas and air to be exposed to a catalyst to generate oxidative reaction heat as a heat source. In the hydrogen combustion device, a hydrogen pipe is arranged in an airflow supply passage and adapted so as to spout hydrogen gas to produce the mixed gas.

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In arrangement, the hydrogen pipe is arranged so as to cross a section of the airflow supply passage in the substantially-diametrical direction. Further, the hydrogen pipe has hydrogen discharge orifices formed in a cross part of the pipe to spout hydrogen gas.

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In the conventional hydrogen combustion device mentioned above, the hydrogen pipe has the hydrogen discharge orifices whose number and position are adjusted in consideration of speed of the airflow, the flow volume, etc. in order to mix hydrogen gas ejected from the hydrogen

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discharge orifices with the airflow effectively.

As a result, the structure of the hydrogen pipe including the number and position of the hydrogen discharge orifices is apt to be complicated and therefore, the number and position of the hydrogen discharge orifices have to be determined upon executing simulation and experiment repeatedly, thereby causing the manufacturing cost of the hydrogen pipe to be increased in its ejecting part of hydrogen gas.

Further, since the hydrogen discharge orifices are arranged so as to oppose the airflow in view of effective mixing of hydrogen gas with the airflow, it is necessary to eject hydrogen gas in opposition to the dynamic pressure of the airflow. Thus, a supply pressure of hydrogen gas has to be increased with the necessity of enhancing the accuracy of a supply route of hydrogen gas in terms of leak-tight capability.

Disclosure of Invention

In such a situation, it is an object of the present invention to provide a hydrogen combustion device having a hydrogen pipe that can simplify the structure of the hydrogen discharge orifices and reduce the supply pressure of hydrogen gas with the improved arrangement of a hydrogen ejecting part of the pipe against the airflow.

According to the first aspect of the present invention, the above-mentioned object is accomplished by a hydrogen combustion device comprising: a casing defining a passage for airflow therein; a hydrogen source arranged outside the casing; a hydrogen pipe arranged so as to extend from the hydrogen source into the passage for airflow thereby to supply hydrogen gas from the hydrogen source into the airflow flowing in the

casing, the hydrogen pipe having a hydrogen pipe body and a hydrogen ejecting part arranged at the leading end of the hydrogen pipe body and also provided with a plurality of hydrogen ejecting orifices; a mixer arranged close to the hydrogen pipe, for stirring the mixed gas; and a combustion catalyst arranged on the downstream side of the mixer in the flowing direction of the airflow to cause an oxidative reaction of the mixed gas thereby generating heat, wherein the hydrogen ejecting part is positioned at a substantial center in the cross section of the passage defined in the casing and also arranged so as to extend along the flowing direction of the airflow, and the hydrogen ejecting orifices are arranged so that their axes extend in the radial direction of the hydrogen ejecting part, substantially perpendicularly to the flowing direction of the airflow.

Then, since the hydrogen ejecting part is arranged, at the substantial center in the cross section of the passage, so as to extend along the flowing direction of the airflow, it is possible to provide the hydrogen ejecting part with the hydrogen ejecting orifices whose axes extends in the radial direction of the hydrogen ejecting part perpendicularly to the airflow. As a result of the formation, it becomes possible to mix the hydrogen gas ejected from the hydrogen ejecting orifices with the airflow effectively.

Therefore, if only forming the plural hydrogen ejecting orifices at substantial-regular interval in the circumferential direction of the hydrogen ejecting part, then the whole structure of the hydrogen ejecting orifices can be simplified to reduce the manufacturing cost of the hydrogen ejecting part.

According to the second aspect of the invention, in the above-constructed hydrogen combustion device, the hydrogen ejecting part is arranged so as to face the upstream side of the airflow and is provided

with a tapered leading end.

Owing to the provision of the tapered leading end, the airflow can flow around the hydrogen ejecting part along the tapered leading end smoothly, it is possible to suppress an occurrence of eddy currents on the upstream side of the hydrogen ejecting orifices, whereby the hydrogen gas ejected from the orifices can be mixed with the airflow effectively.

According to the third aspect of the invention, the hydrogen ejecting part is formed to have the same diameter as that of the hydrogen pipe body and the hydrogen ejecting part is welded to the hydrogen pipe body perpendicularly.

In this case, the structure of the hydrogen pipe as a whole can be simplified.

According to the fourth aspect of the invention, the hydrogen pipe is arranged in a manner that the hydrogen ejecting part takes its position on the upstream side of the mixer in the flowing direction of the airflow, while the hydrogen pipe body takes its position inside the mixer.

With the above arrangement of the hydrogen pipe, it is possible to eliminate an interval between the hydrogen pipe body and the mixer, so that the whole length of the hydrogen combustion device can be shortened to miniaturize the whole hydrogen combustion device.

According to the fifth aspect of the invention, the hydrogen ejecting orifices have different diameters.

According to the sixth aspect of the invention, in connection with the fifth aspect of the invention, the hydrogen ejecting orifice on the upstream side in the flowing direction of hydrogen gas flowing in a straight part of the hydrogen pipe body is formed to have a small diameter in comparison with

the diameter of the hydrogen ejecting orifice on the downstream side in the flowing direction of hydrogen gas flowing in the straight part of the hydrogen pipe body.

5 In this case, the hydrogen ejecting orifice on the downstream side in the flowing direction of hydrogen gas is subjected to a large inertia force of the flowing hydrogen gas. Nevertheless, since the hydrogen ejecting orifice on the downstream side of the hydrogen-gas flow has a small diameter, the flowing resistance of hydrogen gas passing through this orifice is increased. While, the hydrogen ejecting orifice on the upstream side in the flowing
10 direction of hydrogen gas is subjected to a small inertia force of the flowing hydrogen gas. Nevertheless, since the hydrogen ejecting orifice on the upstream side of the hydrogen-gas flow has a large diameter, the flowing resistance of hydrogen gas passing through this orifice is reduced. In this way, owing to this offset effect between the inertia force of the hydrogen-gas
15 flow and the flowing resistance, it is possible to eject the hydrogen gas through both of the hydrogen ejecting orifices having large and small diameters uniformly.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims
20 taken in conjunction with the accompany drawings.

Brief Description of Drawings

Fig. 1 is a sectional view of an essential part of a hydrogen combustion device, which extends from a hydrogen pipe to an electric heating catalyst,
25 in accordance with the first embodiment of the present invention;

Fig. 2 is a perspective view of a mixer and the electric heating catalyst,

in accordance with the first embodiment of the present invention;

Fig. 3 is a perspective view of the electric heating catalyst in accordance with the first embodiment of the invention;

Fig. 4 is a sectional view of a hydrogen supply part of the hydrogen pipe
5 in accordance with the first embodiment of the invention;

Fig. 5 is a sectional view taken along a line V-V of Fig. 4;

Fig. 6 is a sectional view showing the hydrogen supply part of the hydrogen pipe in accordance with the second embodiment of the invention;

Fig. 7 is a sectional view showing the hydrogen supply part of the hydrogen pipe in accordance with the third embodiment of the invention;
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Fig. 8 is a sectional view of the essential part of the hydrogen combustion device, which extends from the hydrogen pipe to the electric heating catalyst, in accordance with the fourth embodiment of the present invention; and

Fig. 9 is a sectional view of the essential part of the hydrogen combustion device, which extends from the hydrogen pipe to the electric heating catalyst, in accordance with the fifth embodiment of the present invention.
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20 Best Mode for Carrying Out of the Invention

Referring to accompanying drawings, embodiments of the present invention will be described below.

[1st. Embodiment]

Figs. 1 to 5 show a hydrogen pipe of a hydrogen combustion device in
25 accordance with the first embodiment of the present invention. In these figures, Fig. 1 is a sectional view of the essential part extending from the

hydrogen pipe to an electric heating catalyst, Fig. 2 a perspective view of a mixer and the electric heating catalyst, Fig. 3 a perspective view of the electric heating catalyst, Fig. 4 a sectional view of a hydrogen supply part of the hydrogen pipe and Fig. 5 is a sectional view taken along a line V-V of Fig. 4.

The hydrogen combustion device is a unit that generates combustion heat by using hydrogen gas as a fuel. The hydrogen combustion device comprises a mixer 10 for mixing hydrogen gas supplied from a hydrogen source (compressed hydrogen tank) with air from an air blower (not shown) to produce uniform mixed gas and an electric heating catalyst 20 for heating and burning the uniform mixed gas to generate combustion gas, as shown in Figs. 1 and 2. The combustion gas produced by the electric heating catalyst 20 is fed to a not-shown combustion catalyst arranged on the downstream side of the catalyst 20 in order to heat it up to a temperature enough for the catalytic reaction.

Further, the combustion catalyst heated sufficiently allows the mixed gas to be oxidized to generated combustion gas of high temperature. Then, the combustion gas of high temperature is fed to a not-shown heat exchanger for heat-changing with a heat-exchanging medium (e.g. pure water) for picking up combustion heat by the combustion catalyst. Noted that the operation of the heat exchanger is described in Japanese Patent Application Laid-open No. 2002-122311.

Meanwhile, the mixer 10 comprises a plurality of successive mixing plates disposed in a cylindrical casing 30 as an airflow passage into which the mixed gas of hydrogen gas and air is introduced. In the shown embodiment, the mixing plates are composed of a first mixing plate 11, a

second mixing plate 12 and a third mixing plate 13 arranged in order from the upstream side of the airflow. These mixing plates 11, 12, 13 are arranged in a manner that their surfaces are perpendicular to the center axis of the casing 30 respectively. Further, the mixing plates 11, 12, 13 are
5 attached to the casing 30 at appropriate intervals in a flowing direction of the mixed gas.

As shown in Fig. 2, the first mixing plate 11 on the uppermost-stream side in the flowing direction of the mixed gas (i.e. the left side in the figure) is doughnut-shaped with a central opening 11a of a large diameter D1. The
10 intermediate second mixing plate 12 has four openings 12a of a middle diameter D2 each in the circumferential direction of the plate 12. The third mixing plate 13 on the downstream side (i.e. the right side in the figure) has a number of openings 13a (eighteen openings in this embodiment) of a small diameter D3 each. For example, the casing 30 has an inner diameter of
15 57.5 mm and the plates 11 to 13 have the diameter D1 of 35 mm, the diameter D2 of 19 mm and the diameter D3 of 9 mm.

Passing through the opening 11a of the first mixing plate 11, the mixed gas entering from the left side in the figure is divided at the openings 12a of the second mixing plate 12 and subsequently divided into smaller flows at
20 the openings 13a of the third mixing plate 13. During the passage through the plates 12, 13, the mixed gas is stirred to mix hydrogen gas with oxygen gas evenly and further supplied to the electric heating catalyst 20.

As shown in Fig. 3, the electric heating catalyst 20 is provided by winding a flat plate 21 laid on a corrugated plate 22, both supporting a
25 catalyst composed of platinum (Pt) of 1 wt % and the remaining alumina (Al_2O_3), and further fitting the resultant assembly into the casing 30 under

pressure. The so-formed electric heating catalyst 20 has a number of cells 33 allowing passage of the mixed gas between the flat plate 21 and the corrugated plate 22.

In order to heat the electric heating catalyst 20, an electrode 24 is
5 attached to the center of the electric heating catalyst 20, while another electrode 25 is attached to the circumferential part of the catalyst 20. In operation, the electric heating catalyst 20 is heated by impressing a current between the electrode 24 and the electrode 25.

After extending from the electric heating catalyst 20 in the introductory
10 direction of the mixed gas once, the leading end of the electrode 24 is led out of the casing 30 through an insulating member 26. The other electrode 25 is led out of the casing 30 through another insulating member 27.

In the first embodiment, as shown in Fig. 1, a hydrogen pipe 39 is arranged so as to extend from the above hydrogen source (not shown) into
15 the casing 30. The hydrogen pipe 39 is formed by a pipe body 40 connected with the hydrogen source to enter the interior of the casing 30 and a cylindrical cap (hydrogen ejecting part) 41 fitted to a leading end 40a of the pipe body 40. Inside the casing 30, the pipe body (part) 40 is arranged on the upstream side of the mixer 10 in the flowing direction of the airflow
20 in order to produce the mixed gas. The pipe body (part) 40 is apart from the mixer 10 at an interval S. Noted that the interval S represents a distance between the sectional center of the pipe body 40 extending across the flowing direction of the airflow and a front surface of the fist mixing plate 11 of the mixer 10.

25 Repeatedly, as shown in Fig. 4, the leading end 40a of the hydrogen pipe 40 is tightly fixed to the hydrogen ejecting part 41 in the form of a

cylindrical cap. The leading end of the hydrogen ejecting part 41 is closed by a blockage plate 41a. Further, the hydrogen ejecting part 41 is provided with a plurality of hydrogen ejecting orifices 42.

5 The pipe body 40 is formed, for the most part, so as to extend from the underside of the casing 30 inward in the radial direction of the casing 30. Further, the pipe body (portion) 40 in the vicinity of the leading end 40a is bent to be substantially perpendicular to the remained portion of the body 40 while being curved toward the upstream side of the airflow. Owing to the formation, the hydrogen ejecting part 41 of the pipe body 40 is positioned at
10 a substantial center of the cross section of the casing 30 while extending along the flowing direction of the airflow (the left-and-right direction in the figure).

In the first embodiment, as shown in Fig. 5, four hydrogen ejecting orifices 42 are formed in the hydrogen ejecting part 41 at regular intervals in
15 the circumferential direction of the part 41. In other words, these hydrogen ejecting orifices 42 are arranged so that their axes (see arrows of Fig. 5) extend in the radial direction of the hydrogen ejecting part 41, substantially perpendicularly to the flowing direction of the airflow. In the hydrogen ejecting orifices 42 shown in Fig. 5, two upper orifices 42a are formed to be
20 small holes, while two lower orifices 42b are formed to be large holes.

Hydrogen gas, which has been supplied from the hydrogen source (not shown) to the hydrogen ejecting part 41 via the hydrogen pipe body 40, is ejected from the hydrogen ejecting orifices 42 into the airflow in the casing 30, thereby producing a mixed gas. Then, the mixed gas is uniformly
25 stirred and subsequently supplied into the electric heating catalyst 20.

In the hydrogen combustion device of the first embodiment, owing to

the above-mentioned arrangements of the hydrogen ejecting part 41 and the hydrogen ejecting orifices 42, it is possible to spout hydrogen gas from the hydrogen ejecting orifices 42 into the airflow, in a radial pattern, whereby the hydrogen gas can be mixed with air effectively.

5 Further, owing to the simple arrangement of the plural hydrogen ejecting orifices 42 at substantial-regular interval in the circumferential direction of the hydrogen ejecting part 41, the structure of the hydrogen ejecting orifices 42 can be simplified to reduce the manufacturing cost of the hydrogen ejecting part 41.

10 Again, since the hydrogen ejecting orifices 42 are substantially perpendicular to the airflow, there is little possibility that the dynamic pressure of the airflow acts on the hydrogen ejecting orifices 42, whereby hydrogen gas could be ejected into the airflow even if a pressure of the hydrogen gas is small. Therefore, it is possible to reduce the supply
15 pressure of hydrogen gas, thereby allowing the supply structure of hydrogen gas to be simplified.

Additionally, it is noted that the hydrogen ejecting orifices 42a positioned on the upper side of the hydrogen ejecting part 41 in Fig. 4 (i.e. downstream side in the flowing direction of hydrogen gas shown with
20 outline arrows of Fig. 5) are formed smaller than the remaining hydrogen ejecting orifices 42b on the lower side of the hydrogen ejecting part 41 in Fig. 4 (i.e. upstream side in the flowing direction of hydrogen gas shown with outline arrows of Fig. 5). The pipe body 40 has a curved portion. The diameter of the hydrogen ejecting orifices 42a on an outer
25 circumferential side of the curved portion is smaller than that of the hydrogen ejecting orifices 42b on an inner circumferential side of the curved

portion. Also noted that the hydrogen gas entering the hydrogen ejecting part 41 via the hydrogen pipe 40 applies a high pressure on the upper hydrogen ejecting orifices 42a due to inertia force of gas-flow in comparison with the lower hydrogen ejecting orifices 42b. Nevertheless, since the diameters of the lower hydrogen ejecting orifices 42b are larger than those of the upper hydrogen ejecting orifices 42a, the lower hydrogen ejecting orifices 42b are easy to spout out hydrogen gas, so that the hydrogen gas can be ejected from the whole hydrogen ejecting orifices 42 uniformly.

In detail, the hydrogen ejecting orifices 42a on the downstream side in the flowing direction of hydrogen gas are subjected to a large inertia force of the flowing hydrogen gas. Nevertheless, since the hydrogen ejecting orifices 42a on the downstream side of the hydrogen-gas flow have small diameters, the flowing resistance of hydrogen gas passing through these orifices 42a is increased. While, the hydrogen ejecting orifices 42b on the upstream side in the flowing direction of hydrogen gas are subjected to a small inertia force of the flowing hydrogen gas. Nevertheless, since the hydrogen ejecting orifices 42b on the upstream side of the hydrogen-gas flow have large diameters, the flowing resistance of hydrogen gas passing through these orifices 42b is reduced. In this way, owing to this offset effect between the inertia force of the hydrogen-gas flow and the flowing resistance, it is possible to eject the hydrogen gas through both of the hydrogen ejecting orifices 42a, 42b having large and small diameters, uniformly.

[2nd. Embodiment]

Fig. 6 shows the second embodiment of the present invention. In this

embodiment, elements similar to those of the first embodiment are indicated with the same reference numerals respectively and their overlapping descriptions are eliminated.

5 Fig. 6 is a sectional view showing the hydrogen ejecting part 41 and the hydrogen pipe body 40 forming the hydrogen pipe 39. According to the embodiment, the hydrogen pipe body 40 is arranged so as to face the upstream side of the airflow and also provided with a tapered leading end 43.

10 In operation, since the airflow can flow around the hydrogen ejecting part 41 along the tapered leading end 43 smoothly, it is possible to suppress an occurrence of eddy currents on the upstream side of the hydrogen ejecting orifices 42, whereby the hydrogen gas ejected from the orifices 42 can be mixed with the airflow effectively. Noted that the hydrogen ejecting orifices 42 have different diameters, as similar to the first embodiment.

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[3rd. Embodiment]

Fig. 7 shows the third embodiment of the present invention. In this embodiment, elements similar to those of the first embodiment are indicated with the same reference numerals respectively and their overlapping
20 descriptions are eliminated.

Fig. 7 is a sectional view showing the hydrogen ejecting part 41 and the hydrogen pipe body 40 forming the hydrogen pipe 39. According to the embodiment, the hydrogen ejecting part 41 is formed to have the same diameter as that of the hydrogen pipe body 40. Further, the so-formed
25 hydrogen ejecting part 41 is welded to the hydrogen pipe body 40 perpendicularly.

Also in this embodiment, four hydrogen ejecting orifices 42 are formed in the hydrogen ejecting part 41 at regular intervals in the circumferential direction of the part 41. As a matter of course, these hydrogen ejecting orifices 42 are arranged so that their axes extend in the radial direction of the hydrogen ejecting part, substantially perpendicularly to the flowing direction of the airflow. According to this embodiment, by the combination of different elements of the same diameter, it is possible to simplify the structure and configuration of the hydrogen pipe 39. Further, in comparison with the first embodiment, there is no need to form the hydrogen ejecting part 41 and the hydrogen pipe body 40 with high accuracy because of the adoption of welding regarding the connection between the part 41 and the body 40.

The other effect and operation of this embodiment are similar to those of the first embodiment.

[4th. Embodiment]

Fig. 8 shows the fourth embodiment of the present invention. In this embodiment, elements similar to those of the first embodiment are indicated with the same reference numerals respectively and their overlapping descriptions are eliminated.

Fig. 8 is a sectional view of the essential part of the hydrogen combustion device, which extends from the hydrogen pipe to the electric heating catalyst. According to this embodiment, the hydrogen pipe body (portion) 40 is disposed inside the mixer 10 while the hydrogen ejecting part 41 is arranged on the upstream side of the mixer 10 in the flowing direction of the airflow.

In detail, the hydrogen pipe body 40 is partially arranged so as to extend between the first mixing plate 11 and the second mixing plate 12. At a substantial center of the cross section of the casing 30, the front part of the pipe body 40 is curved so that its leading end passes through the first opening 11a of the first plate 11 and faces the upstream side of the airflow.

According to the embodiment, owing to the arrangement of the hydrogen pipe 40 inside the mixer 10, it is possible to eliminate the interval S (see Fig. 1) to be ensured between the pipe body 40 and the mixer 10 in the first embodiment, whereby the whole length of the hydrogen combustion device can be shortened to miniaturize the whole apparatus including the hydrogen combustion device.

Also in this arrangement, of course, since the hydrogen ejecting part 41 is positioned on the upstream side of the mixer 10 in spite of the above arrangement of the hydrogen pipe 40, it is possible to produce a mixed gas on the upstream side of the mixer 10 and therefore, the stirring function of the mixer 10 can be effected sufficiently.

[5th. Embodiment]

Fig. 9 shows the fifth embodiment of the present invention. In this embodiment, elements similar to those of the first embodiment are indicated with the same reference numerals respectively and their overlapping descriptions are eliminated.

Fig. 9 is a sectional view of the essential part of the hydrogen combustion device, which extends from the hydrogen pipe to the electric heating catalyst. According to this embodiment, the hydrogen ejecting part 41 at the leading end 40a of the hydrogen pipe body 40 is arranged so as to

face the downstream side of the airflow.

Of course, also in this embodiment, the hydrogen ejecting part 41 is positioned at the substantial center of the casing 30 and further arranged so as to extend along the flowing direction of the airflow.

5 Accordingly, the effect and operation of this embodiment are similar to those of the first embodiment.

Finally, it will be understood by those skilled in the art that the foregoing descriptions are nothing but some embodiments of the disclosed hydrogen combustion device having the hydrogen pipe. Besides these embodiments,
10 various changes and modifications may be made to the present invention without departing from the scope of the invention.

Industrial Applicability

Since the hydrogen ejecting part is arranged, at the substantial center in
15 the cross section of the passage, so as to extend along the flowing direction of the airflow, it is possible to provide the hydrogen ejecting part with the hydrogen ejecting orifices whose axes extends in the radial direction of the hydrogen ejecting part perpendicularly to the airflow. As a result of the formation, it becomes possible to mix the hydrogen gas ejected from the
20 hydrogen ejecting orifices with the airflow effectively.

Therefore, if only forming the plural hydrogen ejecting orifices at substantial-regular interval in the circumferential direction of the hydrogen ejecting part, then the whole structure of the hydrogen ejecting orifices can be simplified to reduce the manufacturing cost of the hydrogen ejecting part.